

Exhibit 2

**UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK**

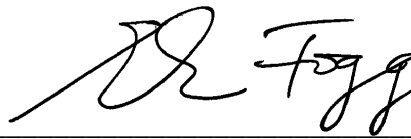
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MDL No 1358 (SAS)
M21-88**

**In re: Methyl Tertiary Butyl Ether (“MTBE”)
Products Liability Litigation**

This Document Relates To:

*New Jersey Dep’t of Env’tl. Prot., et al. v.
Atlantic Richfield Co., et al., No. 08 Civ. 312*

EXPERT REPORT OF GRAHAM E. FOGG, Ph.D.

A handwritten signature in black ink, appearing to read 'G. E. Fogg', is written over a horizontal line.

**Graham E. Fogg, Ph.D.
Carmichael, CA
November 8, 2012**

**DISCLOSURE OF WRITTEN REPORT BY EXPERT
GRAHAM E. FOGG [FRCP 26(2)(B)]**

This written report is submitted in compliance with the disclosure requirements set forth in FRCP 26(2)(B), subject to the right to supplement the report in accordance with FRCP 26(e)(2).

I. EXPERIENCE AND QUALIFICATIONS

1. I am currently Professor of Hydrogeology at the University of California, Davis, a position I have held since March 15, 1989.¹ In that capacity, I have been teaching and performing research on groundwater quantity and quality, with particular emphasis on migration and persistence of groundwater contaminants including nitrate, MTBE, benzene, perchlorate, DBCP, TCE, PCE and salinity. I was Chair of the Hydrology Program of the Department of Land, Air, and Water Resources at the University of California, Davis from 1998 to 2002, and from 2010 to the present. I was Chair of the Hydrologic Sciences Graduate Group at the University of California, Davis from 1993 to 1998 and 2006-present. I am a member in good standing of the American Geophysical Union – Hydrology Division, the Association of Groundwater Scientists and Engineers, the International Association of Hydrologists, California Groundwater Resources Association, and the Geological Society of America. As a Professor it is within my regular scope of employment to participate, review, edit, and evaluate studies of California's groundwater resources. Further, I am a coauthor of "Volume IV: Health and Environmental Assessment of MTBE" (1998 U.C. Report).

2. I have been retained on behalf of the State of New Jersey (Case No. 08 Civ. 312, MDL No. 1358). My time in this matter is billed at the rate of \$250 per hour.

3. Over the last four years, I have testified as an expert witness, either in deposition or at trial, in the following cases:

- County of Suffolk and Suffolk County Water Authority vs. Amerada Hess Corp., et al., and United Water New York vs. Amerada Hess Corp, et al., 2008.
- City of New York v. Amerada Hess Corp., et al. 04 Civ. 3417, 2009.
- Crescenta Valley Water District vs. Exxon Mobil Corp. et al. 07 Civ. 9453 MDL

¹ A copy of my Curriculum Vitae, which includes my publications, is attached as Exhibit A.

No 1358, 2010.

- State of New Hampshire v. Amerada Hess Corp. et al., 2011.
- City of Merced v. Chevron U.S.A., Inc., et al. Case No. 148451, 2011.
- Orange County Water District v. Northrop Corp. et al, 2011.
- City of Merced Redevelopment Agency v. Exxon Mobil Group et al., 08 Civ. 06306, 2012.
- City of Fresno v. Chevron U.S.A. Inc., et al No. 04 Civ. 04973, 2012.

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1 Executive Summary

This Report presents a scientific analysis of the nature of the MTBE's impacts on groundwater in general, and in particular its impact on groundwater resources at identified sites (Trial Sites, or TS) in the State of New Jersey. These sites are:

- TS # 1 Skyline in Ridgewood, Passaic County.
- TS # 2 Valero in Manalapan, Monmouth County.
- TS # 3 Getty West Windsor in Princeton, Mercer County.
- TS # 4 Exxon in Livingston, Essex County.
- TS # 5 Sunoco in Bloomfield, Essex County.
- TS # 6 Hess in Maple Shade, Burlington County.
- TS # 7 Gulf in Waldwick, Bergen County.
- TS # 8 Shell in Ridgewood, Bergen County.
- TS # 9 Points BP in Sewell, Gloucester County.
- TS # 10 H.P. Delta in Woodbridge, Middlesex County.

When evaluating the impacts of MTBE on groundwater, including impacts at the trial sites in this case, it is appropriate to consider (1) the significance of groundwater as a resource, (2) the properties and fate of MTBE, (3) the number and locations of MTBE sources and drinking water supply wells, and (4) fundamental knowledge of groundwater flow and contaminant transport processes, otherwise known as "hydrogeology." In analyzing the impacts of MTBE at the trial sites, it is important to consider the following:

- **The properties of MTBE, together with its high volume of use in gasoline in New Jersey, combine to make it a very potent groundwater contaminant at the trial sites.** The low taste and odor threshold combined with high solubility and relatively high concentration in reformulated gasoline, result in minute amounts of MTBE-containing gasoline polluting large volumes of water, rendering it undrinkable, unless treated. In addition, MTBE is not easily attenuated (i.e., it is not easily biodegraded or sorbed to soil particles) in groundwater.
- **Cleanup of groundwater contamination is difficult, costly and sometimes impossible.** The subsurface is complex, and once a persistent contaminant like MTBE enters the groundwater, it can both migrate rapidly in the fast pathways and be retained in relatively inaccessible portions of the medium from which it can slowly "bleed" out over time scales of years to decades. The retention of groundwater contaminants in inaccessible portions of the subsurface both exacerbates groundwater cleanup and prolongs the presence of the contaminant in the aquifer. Indeed,

subsurface contamination has the potential to threaten drinking supply wells for decades. This is especially true when the contaminant is resistant to biodegradation, as is the case with MTBE.

- MTBE is highly resistant to biodegradation under natural conditions in groundwater systems.** Evidence indicates that biodegradation, should it occur at all, is unlikely to proceed at rates high enough to control plume migration and prevent the spread of MTBE in groundwater to drinking water sources. Natural attenuation through biodegradation cannot be relied upon to protect drinking water sources in groundwater from MTBE contamination. Microorganisms capable of transforming MTBE into less toxic substances do not appear to be either present, or present in significant numbers, at many contaminated sites. Even where such microorganisms are present, many complicating factors inhibit or virtually eliminate significant biodegradation. Laboratory studies point to long periods of time before MTBE degradation occurs; a dependence on the availability of oxygen in many cases; slow growth of microorganisms and slow rates of degradation; inhibitory effects; and incomplete degradation, resulting in the formation of toxic byproducts such as tertiary butyl alcohol (TBA), which is more soluble than MTBE and similarly mobile in groundwater. Compared to other soluble compounds found in gasoline, such as toluene and benzene, MTBE is considered recalcitrant. The use of MTBE isotope ratios or TBA to MTBE concentration ratios as proxy indicators to assess the occurrence and/or extent of MTBE biodegradation tends to be unreliable because of the confounding effects of physical and chemical processes that also affect these ratios.
- While studies have shown that MTBE may degrade under specific laboratory conditions, there is scant evidence to indicate that it can be degraded at appreciable rates under natural, mostly anaerobic, nonengineered conditions common at contaminated sites.** The mere existence of conditions under which a compound might biodegrade neither guarantees, nor implies that the contamination will generally be eliminated or reduced significantly through biodegradation.
- The essence of the MTBE problem is that present-day impacts, which are significant, are not an accurate measure of the ultimate impacts of MTBE. This is because of the long lag time (commonly decades to centuries) in many aquifers between introduction of groundwater contaminants and their arrival at drinking water supply wells.** The properties of MTBE, basic principles of hydrogeology, and past experiences with groundwater contaminants first introduced approximately 50-60 years ago, indicate that MTBE impacts will continue into the future. Basic hydrogeology (i.e., the rate at which groundwater moves) dictates that most MTBE plumes will not reach drinking water supply wells until decades from the time of release. Experience with contaminants like nitrate, TCE, PCE, DBCP, and many others bears out this phenomenon. These groundwater contaminants were introduced initially in elevated quantities circa 1940-1950, yet did not cause appreciable pollution in drinking water wells until the 1970's through the present. It is

noteworthy that nitrate, TCE, PCE and DBCP have all been shown to biodegrade under certain conditions, yet these biodegradation processes are not sufficiently ubiquitous to protect groundwater resources. TCE and PCE, which are less mobile in the subsurface than is MTBE, have contaminated considerable quantities of groundwater over time.

- Many drinking water wells have been impacted by MTBE and many more are vulnerable to MTBE contamination because of the collocation of drinking water supply wells and leaking underground fuel tanks (LUFTs).** There are thousands of public drinking water wells (and many more private wells) in the vicinity of MTBE plumes from leaking underground fuel, or storage, tanks (LUFTs or LUSTs). In New Jersey, for example, by 2001, the State had reported that MTBE was detected in groundwater at concentrations exceeding 70 µg/L, in 80% of the 2,400 LUST cases in which groundwater was being remediated. At the same time, an estimated 15% of public drinking water supply systems (120 out of approximately 800 reporting sampling results by 1998) had MTBE detections above 0.5 µg/L in their water. In private wells, data collected by 2009, indicated MTBE was detected in more than 7.5% of wells at concentrations above 0.5 µg/L.
- Drinking water wells in New Jersey are highly susceptible to contamination.** Aquifers in the Coastal Plain Province of New Jersey consist of unconsolidated media, while aquifers in the northern part of the State are more commonly fractured bedrock. Both types of aquifers are vulnerable to contamination. Drinking water wells near some of the trial sites, located both in the Coastal Plain and in the Appalachian Highlands, have been impacted by contamination released nearby. MTBE has impacted groundwater at all ten of the trial sites.
- Nationwide water quality surveys have shown MTBE to be either the most commonly detected, or the second most commonly detected volatile organic compound (VOC) in subsurface drinking water sources.** The widespread detection of MTBE in water sources in the United States, and in New Jersey in particular, is clearly expressed in many of these reports. MTBE, a compound whose widespread use began only relatively recently, already was detected in 20% of wells in high-use areas and is the second most frequently detected VOC. Further, this contamination is expected to migrate deeper into the subsurface over time, eventually impacting deep water supply wells.
- TBA is a co-product of MTBE and is found as an impurity in the MTBE added to gasoline** The TBA content in MTBE varies widely, and can be as high as 10%. Because TBA is completely miscible with water (no solubility limit), even trace amounts of TBA in gasoline can result in large aqueous TBA concentrations, e.g., hundreds of thousands of ppb, when MTBE oxygenated gasoline comes in contact with water. TBA has impacted groundwater at the New Jersey trial sites.
- Numerous states and countries have moved to phase out MTBE over intervals of several years.** Because of concerns over groundwater contamination, 26 States have taken some form of

action, to either ban or phase out MTBE. The ban on MTBE became effective on January 1, 2009 in New Jersey. Actions to limit the use of MTBE have also been taken in Denmark and Australia, and by refiners in Canada and the U.S.

- **Ethanol, an alternative oxygenate, is easily biodegraded in soil and groundwater.** Therefore, from either neat product or oxygenated gasoline spills, ethanol is not likely to persist in groundwater and will contaminate much smaller volumes of groundwater than will MTBE. In large spills, the preferential biodegradation of ethanol is likely to slow the bioattenuation of BTEX, resulting in increases in the length of some BTEX contaminant plumes in groundwater. However, research indicates that BTEX contamination affected by ethanol can still biodegrade in groundwater. Importantly, data do not show worsening of BTEX effects on drinking water wells during the time period in which MTBE has largely been replaced by ethanol in gasoline
- **Studies indicate that the ethanol concentrations in groundwater resulting from spills of ethanol-oxygenated gasoline meeting the Clean Air Act requirements (<10% by volume ethanol) would not be high enough to have significant cosolvency effects on gasoline compounds in groundwater.** However, at high concentrations, ethanol can induce cosolvency effects on the partitioning of gasoline compounds between gasoline and water. As a result, neat (essentially pure) ethanol spills, e.g., from bulk storage facilities, could result in significant cosolvency effects on contamination present from prior petroleum hydrocarbon spills.
- **For low rate and/or small volume releases, use of ethanol oxygenated (<10% by volume), or MTBE-free gasoline is likely to have considerably less detrimental effects on groundwater quality compared to MTBE oxygenated gasoline.** The most important factor contributing to the differential fate of MTBE and ethanol in the subsurface is biodegradability. The poor biodegradability of MTBE allows for long persistent plumes, exposing larger volumes of water to contamination. Scientific studies have therefore concluded that the impacts from ethanol to groundwater are expected to be “less problematic” and “more manageable” compared to MTBE, and that ethanol is “an acceptable substitute” to MTBE.
- **About 40 percent of the United States public drinking water comes from groundwater and more than 40 million additional people obtain their drinking water from privately owned wells.** The numbers are similar for New Jersey, with approximately 31% of the State’s population relying on groundwater for its drinking supply. Approximately 13% of those who rely on groundwater obtain their water from private wells. The population of New Jersey, is expected to grow, increasing the demand for groundwater. Already though, groundwater is routinely withdrawn at rates far exceeding the rates of replenishment. Groundwater contamination that renders significant volumes of water undrinkable is, at best, highly undesirable or, at worst, disastrous for the public.

The impacts of MTBE on groundwater, as described above, can be seen in data and information regarding the trial sites in this case. As explained in more detail in this report, the impacts of MTBE on groundwater at the trial sites reflect the same characteristics as MTBE at other groundwater contamination sites in New Jersey and elsewhere.

2 Introduction

In this report, I review the scientific evidence concerning the behavior of MTBE in the subsurface in general, and comment on the consequent threat to drinking water resources, in the context of specific locations (Trial Sites) in New Jersey. I also discuss ethanol in a similar context. A copy of my *curriculum vitae* (including a list of publications and my experience as an expert witness) is included as an appendix at the end of this report.

This written report is submitted in compliance with the disclosure requirements set forth in FRCP 26(2)(B), subject to the right to supplement the report in accordance with FRCP26(e)2. The exhibits that will be used to summarize or support the opinions expressed in this report are the exhibits which appear in, or are transmitted with, this report. The exhibits may later be enlarged, set into a Powerpoint or similar electronic presentation format, or otherwise presented in a manner appropriate to the proceeding where they are used. I may use blow-ups of charts and tables from this report when testifying to the jury. In the course of this work I was compensated at a rate of \$250 per hour, and none of the compensation was contingent on the content of this report.

2.1 Scope of the Problem

The properties of MTBE – particularly, its solubility, mobility and persistence – as well as its use in gasoline at high volumes, “a highly dispersive use” (*Hanson et al., 2008*) - make it a potent contaminant in groundwater. MTBE has low taste and odor thresholds, and is highly soluble in water. In addition, MTBE was used at a relatively high concentration in reformulated gasoline (11% and higher). As a result, minute amounts of MTBE-containing gasoline have polluted large volumes of water, to the point where that water is no longer drinkable. In addition, MTBE is not easily attenuated (i.e., it is not easily degraded or sorbed to soil particles) in groundwater.

MTBE was approved for use as an octane booster in 1979 (*Zogorski et al., 2006*). By 1980, MTBE had contaminated drinking water supplies in the Rockaway Township of New Jersey (*McKinnon and Dyksen, 1984*). The problem was discovered when residents complained of taste and odor problems in their water. MTBE and diisopropyl ether (DIPE; another fuel oxygenate): “were found at sufficiently high levels to cause severe taste and odor problems in the water...As a result, numerous taste and odor complaints were received from the township’s residents” (*McKinnon and Dyksen, 1984*).

2.1.1 MTBE in New Jersey under CAAA

With the passing of the Clean Air Act Amendments (CAAA), New Jersey was required to enact two types of oxygenated gasoline programs:

- Wintertime Oxygenated Fuels Program: Under the CAAA, New Jersey was required to implement the wintertime oxygenated gasoline program to help control carbon monoxide emissions. The program required a 2.7% oxygen

content by weight, which amounted to 15% MTBE by volume. Thirteen¹ of the northern New Jersey counties implemented the program for a six-month control period between October 1, 1992 and March 31, 1993. The remaining eight² southern counties implemented the program for a four-month control period from November 1, 1992 through February 28, 1993 (NJDEP, 2001). In 1995, the program was repealed in southern New Jersey, after attainment of the National Ambient Air Quality Standards (NAAQS) for carbon monoxide (CO). In 1997, the New Jersey Department of Environmental Protection (NJDEP) submitted formal requests to the USEPA to end the Wintertime Oxygenated Fuels Program in the northern counties based on attainment of the NAAQS for CO, and because of concern over the discovery of MTBE in water supplies across the country. The request was approved in June of 1999.

- Reformulated Gasoline Program (RFG): the State was required (under the CAAA) to implement the RFG program starting in January 1995 because New Jersey fell within the NAAQS ozone nonattainment areas of the United States. Under RFG, gasoline contained 2% oxygen, the equivalent of 11% MTBE by volume. Reformulated gasoline was used in all counties in the State. In 2005, the State legislature issued a ban on the sale of gasoline containing more than 0.5% MTBE, effective January 2009. It is believed however, that the use of MTBE in gasoline in New Jersey dropped significantly after 2006³.

Soon after widespread use of MTBE in New Jersey, the State reported in 2001 that based on data from the Bureau of Underground Storage Tanks (BUST), MTBE was “present in groundwater at concentrations exceeding 70 µg/L in 80% of the 2400 leaking underground storage tank cases in which groundwater is being remediated” (NJDEP, 2001). The State also noted that because of MTBE’s “high solubility and resistance to degradation” it moved in groundwater with “very little retardation.” Changes in groundwater flow direction and pattern in response to local water usage in areas where there is MTBE groundwater contamination “increases the likelihood for impacts to potable wells from MTBE. Currently, there are more cases in BUST at which a potable well was impacted by MTBE than any other gasoline related compound. In addition, some potable wells impacted by MTBE are reported to the Department based on taste and odor

¹ The Northern counties included: Sussex, Passaic, Bergen, Warren, Morris, Essex, Hudson, Union, Hunterdon, Somerset, Middlesex, Monmouth, and Ocean.

² The Southern counties included: Mercer, Burlington, Camden, Gloucester, Salem, Atlantic, Cumberland, and Cape May.

³ <http://www.epa.gov/oms/regs/fuels/rfg/properf/atcty-nj.htm> last accessed October 26, 2012.

problems at levels below the MCL of 70 µg/L” (*NJDEP, 2001*).

The New Jersey Bureau of Safe Drinking Water started collecting data on MTBE in public water supplies in 1997. Between July 1997 and September 1998, an estimated 400 out of 614 (65%) public CWS, and 397 out of 1,100 (36%) non-transient non-community water supply systems reported results to the Bureau. The regulations required that the samples are collected from the “point of entry to the distribution system” (*NJDEP, 2001*) or in other words, water delivered to consumers.

The results indicated that 15% of CWS and 16% of non-community non-transient systems had MTBE detections in their drinking supplies at concentrations between 0.5 and 20 µg/L. Two of the non-transient non-community water supply systems reported MTBE concentration greater than 20 µg/L, with one system reporting a concentration of 130 µg/L. While MTBE detections were mostly below the State set MCL, it was noted that MTBE, though only in use for a relatively short period of time, was the most frequently detected volatile organic chemical (VOC) at approximately 15% detection frequency in public supply wells. The next most frequently detected VOCs were trichloroethylene (TCE), tetrachloroethylene (PCE), and 1,1,1-trichloroethane with detection frequencies of 8-9%.

A review of the historical MTBE sampling data from the New Jersey public water supply compliance database (SDWIS database) shows that concentrations above the state's MCL of 70 ppb have been detected in public water supply system(s) in nearly every year since 1997 (Figure 2.1). Figure 2.2 shows the locations of (geolocated) public water supply systems, the trial sites, and other known MTBE sites. Table 2.1 sums the populations served by systems with detections at or above particular concentration thresholds. More than 4 million people were served by systems with historical detections of MTBE at or above 1 ppb. However, it is not known how many people served by those systems actually consumed water with MTBE at those levels. The SDWIS data are useful in assessing the relative vulnerability of public wells in regions associated with the trial sites (see Section 4).

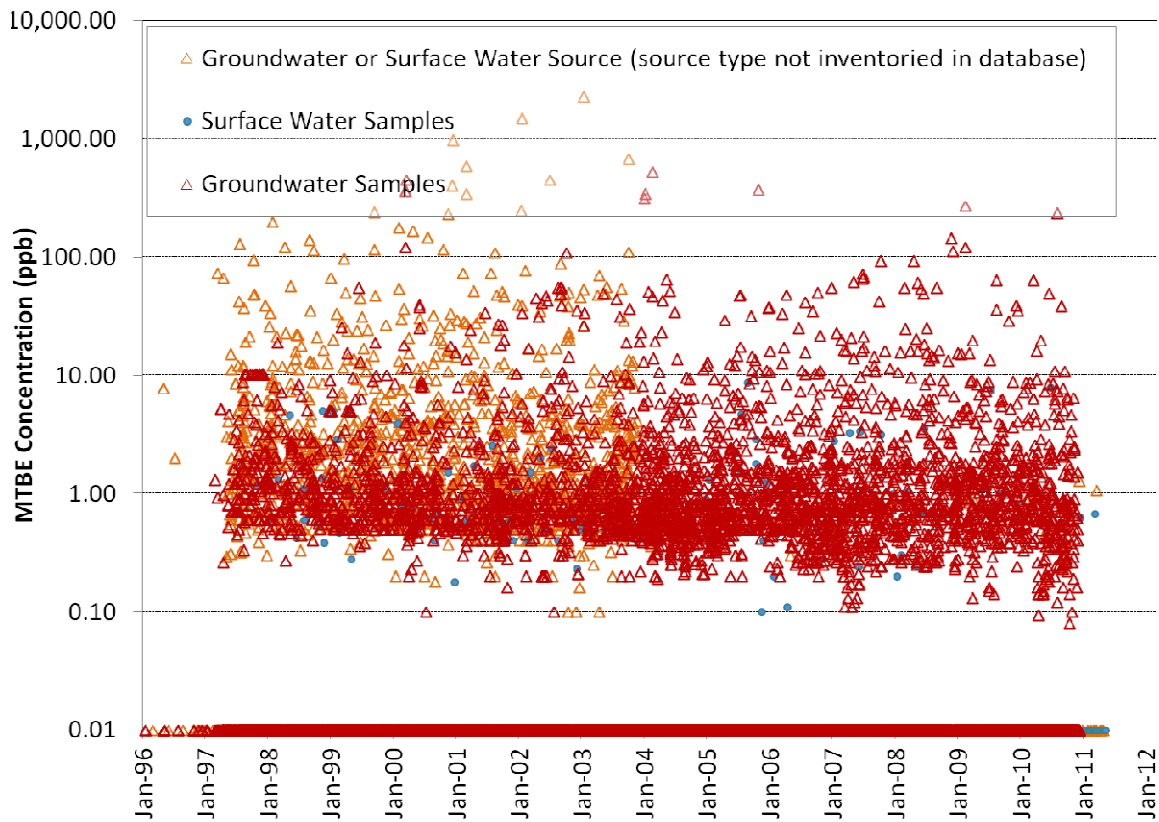


Figure 2.1. MTBE sample results for testing of public water supply systems in New Jersey from 1996 through 2011. Concentrations above the State's MCL of 70 ppb have been detected in nearly every year since 1997. Nondetects were plotted as 0.01 ppb.

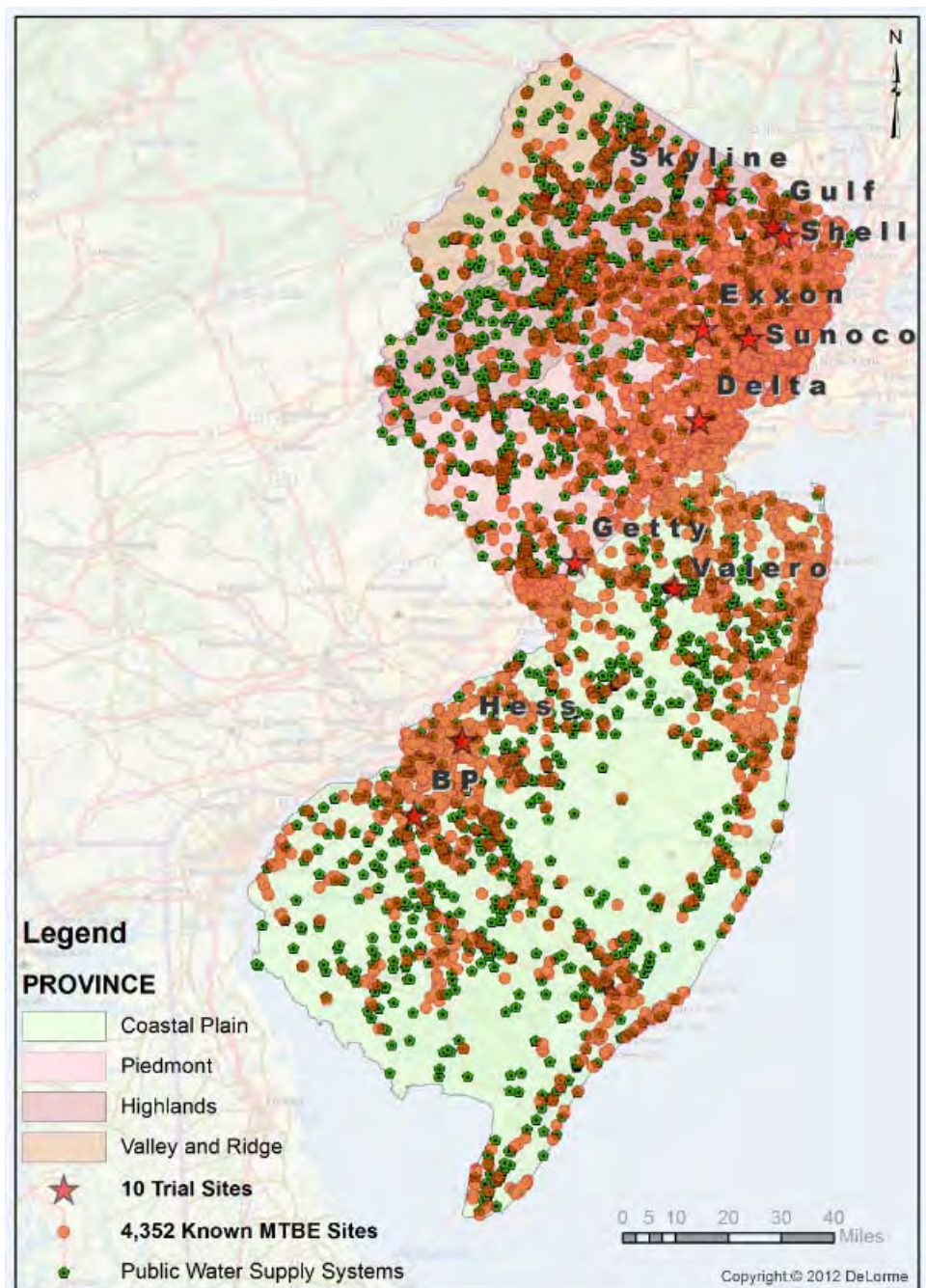


Figure 2.2. The trial sites, other known MTBE sites, and public water supply systems plotted against the physiographic provinces of New Jersey.

Table 2.1: The population served by systems with MTBE detections at or above specified concentration levels. It is not known what fraction of the population served by such systems actually consumed MTBE at the levels shown. Data are from the State's SDWIS database.

Concentraion Range (ppb)	Population Served by System
>= 70	219,846
>= 10	1,461,797
>= 5	2,591,786
>= 1	4,690,964
Detection at Any Level	6,097,511

A review of the historical data revealed more than 4,300 known sites with MTBE contamination across the State. The 4,300 known MTBE sites are a fraction of the total number of MTBE sites, since some sites are unknown. The location of the known MTBE sites in relation to some of the private wells can be seen in Figure 2.3⁴. Private well testing under the Private Well Testing Act (PWTa) includes testing for MTBE.

Currently, 10 years after the start of the PWTa program, only a fraction (approximately 20%, 84,898 wells) of the approximately 400,000 private wells in the state have been tested for MTBE. As of June, 2011, MTBE had been detected in 4,108 private wells (4.84%, approximately one in twenty) at concentrations at or above 1.0 ppb. Based on those data, an estimated 19,355 private wells serving 47,924 people have been impacted by MTBE at concentrations at or above 1 ppb. Like the public water supply well data (SDWIS data), the PWTa data are useful in assessing the relative vulnerability of private wells in regions associated with the trial sites (see Section 4).

⁴ Locations of private wells are approximate because they have been randomized on a half mile square grid to protect the privacy of well owners. "In March 2001, the New Jersey Private Well Testing Act (PWTa) was signed into law, and its regulations became effective in September 2002. The PWTa is a consumer information law that requires sellers (or buyers) of property with wells in NJ to test the untreated ground water for a variety of water quality parameters," Atherholt et al., 2009. Accessed at <http://www.state.nj.us/dep/dsr/research/pwta-overview.pdf>.

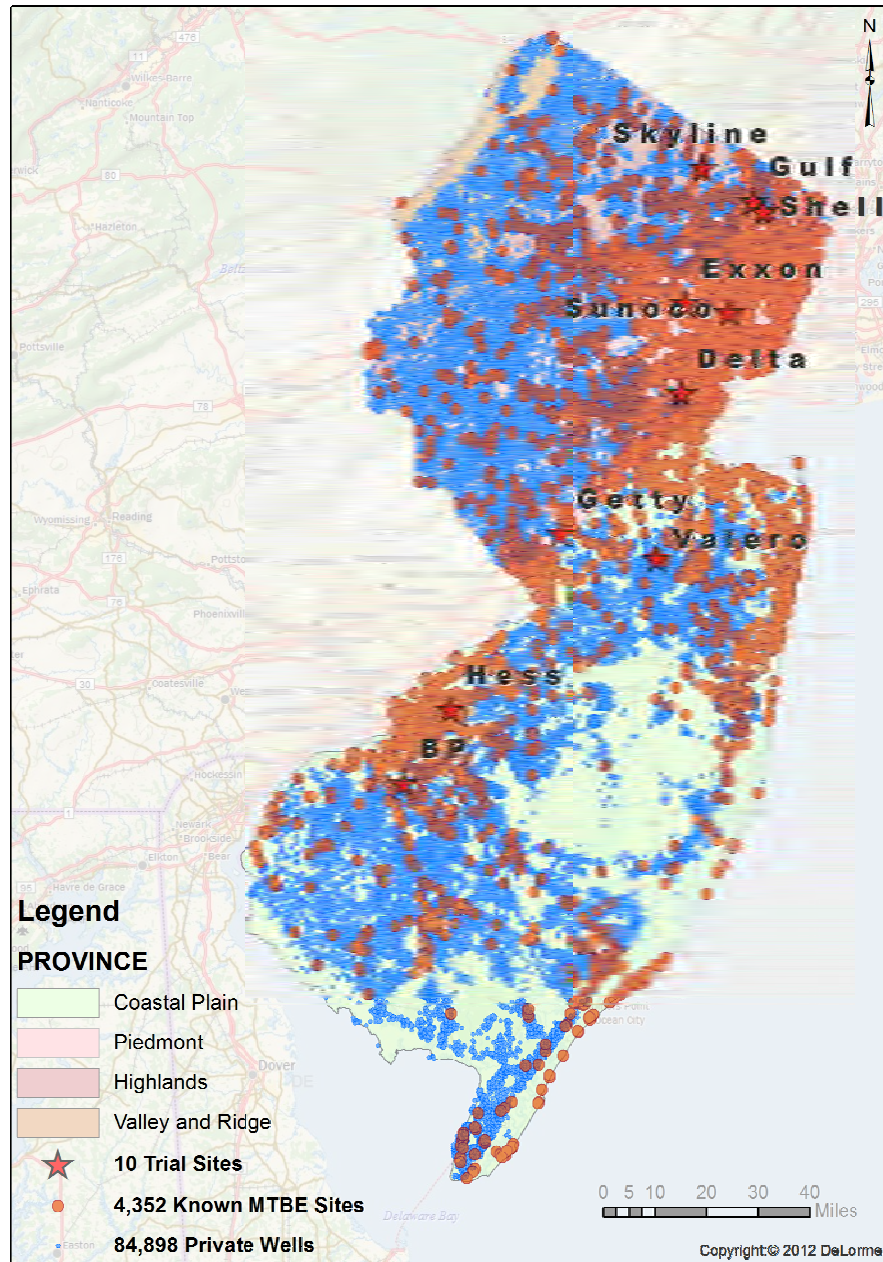


Figure 2.3. Location of the trial sites and other known MTBE contamination sites in the State, in relation to the location of the private wells that have reported groundwater sampling analysis under the Private Well Testing Act (as per the most recent data from the State). Note that the New Jersey has an estimated 400,000 private well, and approximately 20% of those wells are plotted.